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CONTENTS.

Plant Physiology: PROFESSOR BENJAMIN M. DUGGAR 937

Scientific Books:—
Shattuck on the Bahama Islands: W. M. D. 953

Societies and Academies:—
The Philosophical Society of Washington: CHARLES K. WEAD. *The Science Club of the University of Wisconsin:* F. W. WOLL. *The San Francisco Biological Club:* PROFESSOR W. J. V. OSTERHOUT. *The Psychological Club of Cornell University* 955

Discussion and Correspondence:—
An Automatic Catalogue of Scientific Literature: G. N. COLLINS. *'Life and Chemistry':* PROFESSOR M. A. BRANNON 958

Special Articles:—
The Ideas and Terms of Modern Philosophical Anatomy: PROFESSOR HENRY F. OSBORN. *Some Ph.D. Statistics:* PROFESSOR RUDOLF TOMBO, JR. 959

Botanical Notes:—
Michigan Forestry; A New Book on Ecology; Original Descriptions of Species; North American Rusts: PROFESSOR CHARLES E. BESSEY 963

Museography: C. R. E. 964

The University of Wisconsin 964

The Museum of the Brooklyn Institute 965

Award of the Barnard Medal 965

The American Anthropological Association .. 966

Scientific Notes and News 966

University and Educational News 968

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*PLANT PHYSIOLOGY—PRESENT PROBLEMS.**

To the very year one century has elapsed since Theodore de Saussure published his remarkable investigations relating to the nutrition of plants and to the influences upon plants of certain well-known physical forces. Although preceded by the publications of Duhamel, Hales, Ingenhouss and Senebier, as well as by those in a somewhat different line, by Konrad Sprengel and others, we may look upon the work of de Saussure as a wonderful production for his time and as strikingly indicative of the status of plant physiological problems a century ago. His paper may be regarded in a sense as the original charter or constitution of plant physiology. Fortunately, it is assigned to an eminent and experienced botanical historian to recite the amendments which mark the wonderful growth of this historic instrument. There remains, therefore, the task of suggesting some directions of future growth.

No distinction need here be made between those problems which are readily seen to involve the closest work in such other sciences as physics and chemistry and those which do not show a relationship so close. There is certainly much in physiology which must be based upon physics and chemistry, but when dealing with the causes of the activities of living organisms, it is in relatively few cases that explanations may ever be offered in terms of

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physics and chemistry alone. Nor is it possible to offer such explanations without the assistance of these sciences. The progress of the work in physiology is indissolubly bound up in the development of other sciences. The benefits are, however, mutual, and as physiology acknowledges the fundamental importance of these related sciences, they in turn must acknowledge the important contributions, often of fundamental nature, which have resulted through physiological investigation.

In such a paper it would be impossible to do more than outline briefly some of the relationships of special problems which, for one reason or another, merit emphasis. In general, the problems in plant physiology have been well brought out and systematized through the monumental work recently completed by Professor Pfeffer. To him the science owes a debt of gratitude which may be acknowledged as well by one who attempts to suggest future work as by the historian. Again, due recognition should be made of those who have in recent years based upon this or any similar topic valedictory addresses before various botanical organizations—notably, those of Professors Vines, Ward, Barnes, Reynolds Green and others.

The fact that every cell or organ requires its food materials, or at least its nutrients, in liquid form, readily emphasizes the fundamental importance of those problems suggested by the relation of the plant to solutions. The mechanisms for absorption and the general and special diosmotic properties of the living cell, all of which have been studied with the most consummate skill, have yielded matchless results; yet the rewards for future research show at present no distinct limitations. It has not been possible to determine the nature of the plasmatic membrane which directly or indirectly possesses such marked powers of selection and accumulation. The conditions under which the activities of this membrane may be modified are but poorly understood; and it is, perhaps, quite beyond the present possibilities to determine the mechanism of this modification, for in that must be involved one of the most important vital activities of protoplasm. Perhaps, when much more data have been accumulated by a study of plants of diverse habitat, the conditions of this modification may be more clearly distinguished. It is known that continued endosmosis of a particular solute depends largely upon the use or transformation of this solute within, yet it is not always possible to demonstrate any change in the substance absorbed. In any event, it is necessary to ask further light upon the exosmotic resistance of the plasmatic membrane to the accumulation of turgor-producing substances, or, in other words, to a further explanation of what may be termed one way penetration. To these phenomena the processes of excretion and secretion are closely allied, whether they are ultimately, periodically, or continuously the function of certain protoplasts.

Further chemical knowledge is needed dealing with the meaning of high pressures and of the accommodation of very high pressures in the fungi. As a rule, those protoplasts seem to be resistant to such high pressures which are also resistant to cold, desiccation and other stimulation. Mayerburg, working under the instruction of Professor Pfeffer, has recently applied himself to a study of the method by means of which the organism may regulate its turgor. It is evident that one of two propositions must be assumed, and that increased turgor may be produced either (1) by the penetration of substances from without, or (2) by substances of strong osmotic action produced within the cell

through the stimulative action of external agents. It was determined in this case that in general no absorption of the substances bathing the plant occurs; therefore, osmotic substances are produced within the cell and largely by increased concentration of the normal organic cell products. The extent and method of this capability for turgor regulation are highly important, as is also the general question of the relation of turgor to growth. In recent times some of the important problems in this connection have been well suggested by the work of Ryssleberghe, Puriewitsch, Overton, Copeland and Livingston.

The absorptive systems of plants seem to be admirably adapted for their needs from a diosmotic point of view. Diffusion may, therefore, be sufficiently rapid to supply all demands of the absorbing cells or organs. Nevertheless, the assumption that ordinarily diffusion through the cell and plasmatic membrane is sufficiently rapid properly to provide for the translocation of metabolic products from cell to cell is certainly open to further inquiry. Present knowledge of the translocatory processes is insufficient. Plasmatic connections between cells are now known to be of common occurrence, and this fact has given further interest to the above inquiry. Brown and Escombe are of the opinion that the plasmatic connections are eminently adapted for all of those phenomena which they have found to belong, as subsequently mentioned, to multiperforate septa. They claim, further, that with slight differences of osmotic pressure the necessary concentration of gradient for increased translocation would be very simply effected.

Thus far it has been difficult to throw any light upon cell-absorption and selection in many complex natural relationships by calling in the assistance of the dissociation theory and the ionic relationships of the salts in the soil. The external relationships of nutrient salts, or the relative abundance of these in substrata supporting vegetation, constitutes a problem with which the physiologist must be concerned. It is only necessary to glance at the results of work done by various experiment stations in this country to be convinced of the great physiological importance which may be attached to such studies.

Recent results tend to emphasize the importance of considering to a greater degree the physical conditions of the soil. Some have even gone so far as to claim that practically all soils contain a sufficient quantity of plant food; and that the all-important question is the regulation of the water supply in accordance with the quality of the particular soil. This latter, however, is an error into which few physiologists have fallen. Nevertheless, precise studies upon the relation of plants to the physical characters of soils afford problems which should receive the best attention. Many of the problems are not new, and in a qualitative way, at least, the problem of the relationship of the conservation of moisture and the tilth of the soil to productiveness has been duly appreciated by the best agronomists. We must notice with regret, therefore, that botanists have not always appreciated the importance of such work. Either directly or indirectly the water factor is a chief one in regulating the activities of the living plant and must be considered from every possible point of view.

It may, perhaps, be less a problem than a routine matter to determine the relation of the rate of absorption of salts in the soil solutions to water under the varying conditions of growth and transpiration. Nevertheless, information of this nature is important.

In spite of all the recent work, the phys-

ical explanation of the ascent of water in trees is a problem which must be mentioned. The renewed investigations which have been made along this line from an objective point of view will undoubtedly contribute to its eventual solution.

It is a matter of interest that in their studies of the physics of transpiration, Brown and Escombe have found evidence to regard this process also as a matter of diffusion through multiperforate septa, rather than a matter of mass action. It is calculated that by diffusion water may pass out of the stomates to an extent as much as six times the actual amount of transpiration which has been observed in special cases.

The great number of cytological investigations which have been completed within the past ten years indicate notable advancements in a most important field; and this is particularly true with relation to the study of nuclear phenomena. Through this work light has been thrown upon many problems of cell physiology and of development: and as a result of the latter new theories of heredity have been advanced. Nevertheless, the field for investigation has been constantly broadened and many new lines of research made possible. In spite of the excellent results accomplished, there is yet great uncertainty as to the interpretations which have frequently been made. In no field of work, perhaps, is it possible for the personal factor to enter into the results more largely than in this. Again, it is unfortunately true that fixed material has been studied almost to the exclusion of all other and that even general observations relating to the conditions of growth have been omitted in many instances. Much attention has been bestowed upon the minutest details which seem to be of morphological significance in the nucleus; but often the purely physiological side has been insufficiently emphasized. It is quite possible that in different plants, the exact method of chromosome division, or the manner of nucleolar disappearance, may not be similar; and it is certainly well known that external conditions may considerably modify the details of spindle formation, and perhaps other details in nuclear and cell division. The important point in every case is to determine if the same physiological purpose may be accomplished.

It is extremely important, however, to the subject of physiology that the methods which have made possible these cytological advances shall be extended and utilized in developing a knowledge of all of the various activities of the cell. In this way, a clearer insight may be given of many abstruse metabolic processes; and certainly further light may be thrown upon the matter of protoplasmic decompositions and secretions, the production of enzymes and alkaloids, tannins and other products. Going hand in hand with observations upon fresh material, the limitations of microchemistry alone should determine the possibilities in this direction of the work.

In such cytological investigations, Fischer's work on the artificial production of effects resembling those seen in fixed protoplasm should be borne well in mind. This work is timely, and may assist in checking irrational developments by forcing a proper regard for a comparison of the effects observed in fixed tissues with those shown by the living material.

There are, moreover, but few directions in which the study of metabolism and metabolic products may not profit from cytological research. A notable instance of what there is to be done is well indicated by the work of the late Dr. Timberlake on the division of plastids and the development of the starch grain.

Photosynthesis is a topic which has received a full share of physiological investigation throughout the past century; yet the problems demanding attention are too numerous for complete enumeration. The mechanism of gaseous exchange in leaves has repeatedly been experimentally proved to be the function of the stomates. After critical physical experimentation, Brown and Escombe have recently reported that the results of their studies of diffusivity through multiperforate septa are closely applicable to the herbaceous leaf with its stomates and substomatic chambers. Assuming their calculations to be correct, and granting that all of the incoming carbon dioxide is removed, it is estimated that with the stomates open the maximum observed rate of fixation of CO_2 in *Helianthus* (which is .134 c.c. per square centimeter per hour) would be only 5.2 to 6.3 per cent. of the theoretical capacity of the diffusion apparatus of the plant. In other words, with a gradient between the outer and inner air of only 5 to 6.5 per cent. pressure, the maximum observed fixation is well accounted for.

Important problems in the general study of photosynthesis may well begin with that of a better knowledge of the structure of the chloroplasts and the constitution of chlorophyll. Neither of these, however, is absolutely essential to further physiological observations of a fruitful kind. One of the questions long ago raised is still pertinent: what is the connection between chlorophyll and the plastid in which it is embedded? An answer to this question may perhaps afford in time an answer to the general inquiry as to the location of the true photosynthetic property. If chlorophyll is always the same chemically, it is perhaps probable that the first product of photosynthesis may always be the same, although this is not necessarily true. In any case, the chief problems hinge upon the method of decomposition of carbon dioxide and water and the synthesis of the first organic product. Neither the hypothesis of Bayer, Erlenmeyer, Crato, Bach, Putz, nor any other, has, to any considerable degree, been made capable of experimental proof, although that of Bayer has been most generally accepted. Each of these assumptions offers some suggestions for future work. Perhaps it may as well be said that they, to a certain extent, bias future research. Nevertheless, even when the chemical reactions in this synthesis become known it may yet remain problematical how the energy of sunlight, that is, of those rays most absorbed, with wave lengths of 660 to 680 μ is made available, or whether it is this energy directly or indirectly which is concerned in the decomposition. It has been well assumed that the light waves may not be immediately serviceable, but only after transformation into other forms of energy. Further, it is not known to what extent this energy is operative in subsequent transformations. The conditions under which photosynthesis occurs have been worked out with a fair degree of accuracy, the status of these problems having been well set forth by Ewart and others. It is known that when deleterious agents act at a given concentration merely to inhibit the assimilatory function (the cell not being permanently injured) there is no evident change in the chlorophyll, from which it has been inferred that the assimilatory arrest has its origin in the plasmatic stroma. In all cases photosynthesis can not long proceed except under conditions of health of the protoplasts. Nevertheless, the effects of deleterious agents have not always been studied by very delicate tests, and further attention might be bestowed upon this matter by the use of the photobacterial method,

or other delicate methods, recently suggested, for it is of considerable interest to determine the relation of the photosynthetic activity to such agents as compared with other activities.

Recently the effects of temperature on photosynthesis have been carefully worked out by Miss Matthaei. She states that the curve of synthetic activity rises with increased temperature, that it is in general convex to the temperature abscissæ and somewhat similar to the curve of relation between temperature and respiration. There is a certain maximum for each temperature. It has also been ascertained that there is a certain economic light intensity beyond which there is no increased photosynthetic activity, and doubtless only injury. This is of special interest in connection with some recent work by Weis. Recognizing the fact that plants are of very different types with relation to their light requirements, he has sought to get an expression of their assimilatory energy. He finds that *Œnothera biennis*, a well-marked sun plant, fixes under favorable conditions of temperature, and in direct sunlight, about three times as much CO_2 as in diffuse light (light of one sixtieth to one ninetieth this intensity). On the other hand, *Polypodium vulgare* assimilates in diffuse light somewhat more energetically than in direct, while *Marchantia polymorpha* occupies a position intermediate. This will be welcomed by physiologists as a field for wholesome ecological study, for an extension of such investigations to an analysis of plant associations with relation to the light factor may yield profitable results.

In 1901, Freidel made the surprising report of success in securing outside of the living plant a gas exchange similar to the photosynthetic action of chlorophyll. He was later unable to confirm his previous conclusions, nor were the subsequent results of Macchiata and Herzog concordant. Recently, Molisch has employed upon this problem the photobacterial method of Beijernick. He finds that the expressed sap of certain plants may for a time maintain photosynthetic activity, but since usually the sap loses this power when filtered through a Chamberlain filter, it is believed to be due to the presence of living plasmatic particles. Nevertheless, it is claimed that an exchange of gases characteristic of photosynthesis may proceed in a solution of the leaves of *Lamium album* dried crisp at 35° C. and then 'rubbed up' in water and filtered. The observation demands much further study, for it must be remembered that the test is by means of the liberation of oxygen, and Ewart has shown that some bacterial pigments may have the power of evolving oxygen. In the last-named case the gas evolved appears to be, as he states, 'occluded oxygen absorbed from the air by the pigment substance excreted by the bacteria.'

It can not be stated at the present time, however, as was assumed from Freidel's first work, that there is any enzyme concerned in the photosynthetic activity.

To a large extent the problems involved in a study of the assimilation of nitrogen are limited by the very imperfect chemical knowledge of nitrogenous products, and may not, therefore, be very clearly defined. Practically, the whole question of the formation of amides, proteids or other nitrogenous compounds in plants remains in obscurity. It is known that these are formed in both non-chlorophyllous and chlorophyllous plants and that while in the former it may proceed in darkness, in the latter, light is apparently required for the most vigorous synthesis. In the latter case it may seem to suggest that there is need of the active cooperation of the chlorophyll apparatus; but here again the influence may

be only indirect, since the roots, as well as the aerial parts of chlorophyll-bearing plants, are said to possess, to a certain extent, this synthetic power. Interesting suggestions have been recently made by Godlewski. The part played in photosynthesis by nucleus and cytoplasm, respectively, is unknown and may be important.

Some careful studies have been made dealing with the sources of organic nitrogen in certain of the molds, but owing to the very great variety of fungous habitats, further studies may indicate unusual specialization—perhaps even to such extent as is now known to be true with the bacteria.

Saida has confirmed and extended the early work of Puriewitsch and others, clearly demonstrating that under certain conditions some of the fungi are able to utilize to a variable degree the atmospheric nitrogen. It would be interesting in this connection to give further attention to various groups of saprophytic fungi. In a public lecture Moore has recently made known the results of remarkably definite experiments showing that the organism (or organisms) of leguminous tubercles assimilates free nitrogen apart from its hosts, and that, therefore, the symbiotic association gives the parasite no nitrogen-assimilating advantages. Moreover, this nitrogen assimilating capacity increases under conditions of artificial culture, and this increased power is heritable to a considerable extent at least. This is an important fact and deserves further attention.

Recently Reinke, Benecke and others have focused our attention upon the nitrogen supply in sea water. They find that the organisms *Clostridium Pasteurianum* and *Azotobakter chroococcum* are found in the ooze of sea bottoms; and the suggestion is made that the external but, nevertheless, close association of these micro-organisms with certain marine algæ may explain the power of these algæ to grow so vigorously in situations in which they are found. The nitrogen supply is probably one of the most important problems relating to the marine algæ. It is to be borne in mind, however, that the question of fundamental interest is always that of how these micro-organisms are able to utilize the nitrogen which is absorbed in gaseous state. No such power is known among phanerogams. It has not yet been demonstrated to be possible with the lower algæ, and certainly none of the interesting results so far obtained indicates that it is a very fundamental character of fungi and bacteria. In this connection, perhaps, it may also be stated that nothing whatever is known concerning the method by which carbon dioxide is chemo-synthetically utilized by the nitrite and nitrate bacteria.

There are many interesting problems afforded by the general phenomena of metabolism, with relation both to those products which may be immediately utilized and to those which may be stored up for future use. It is well known that during active growth special foods may be taken out of circulation and stored up. The stimulus to such storage is not easily determined. In many instances it is apparently the protoplasm which is decomposed in order that these storage products may be formed; therefore, so far as possible a study of all protoplasmic decomposition phenomena is especially necessary. The deposition of the cell plate and the storage of reserve cellulose are especially interesting. It will be extremely difficult to follow the succession of changes involved, yet some information will undoubtedly be gained.

The migration of compounds, particularly of those containing nitrogen, magnesium and potash, to growing vegetative

parts and to the developing seed is most remarkable. The production, whether regulatory or otherwise, of the numerous by-products in the cell, such as tannin, pigments, organic acids, etc., is also of peculiar interest. The functions of some of these compounds must be most important, and should receive further attention. Tannin, particularly, is doubtless of much economic importance in the regulation of turgor and in augmenting the resistance to injurious external agents. Astruc has recently shown that acids are found in the younger parts of non-succulents and mostly in the region of maximum turgescence; and that there is a progressive decrease of such compounds in the older organs. In succulents, moreover, very slight changes in the external conditions materially affect the acid content.

It can not be expected that all of the information desirable with relation to the composition and action of hydrolyzing and oxidizing enzymes will be obtainable until more is known of the proteids, to which group the ferments seem to belong, or with which they are at least closely related. Whether these enzymes are concerned with the metamorphoses involved in rendering soluble or transforming pectin, proteids, glucosides, starches, cellulose, fats, or sugars, their physiological activities are in the highest degree remarkable, and worthy of the closest study. The problems which relate to their occurrence, composition, production and action require, however, the combined attention of physiologists and organic and physical chemists. In recent times, through the work of Brown and Morris, Fischer, Green, Prescott, Vines, Loew, Beijerinck, Newcombe, Woods, and many others, these compounds have received renewed attention. It may be that at present too many obscure phenomena are passed over with the superficial explanation that they are the result of enzyme action, and, therefore, require no further consideration. It is known that the ferments are largely concerned with the regulatory production of modification of numerous metabolic products. The activity of each enzyme is circumscribed, yet the power to do work borders upon the miraculous. It is asserted that invertin may invert 100,000 times its volume of cane sugar, and pepsin may transform 800,000 times its volume of proteids. The chemist is especially concerned with the composition and occurrence of these, but the physiologist is interested not alone in the occurrence and specific action of the enzymes, but also with the effects upon the general metabolism of the individual plant, with the methods and conditions regulating the secretion of these products, and with their vitalities or limiting external conditions. Ferments may be concerned with external cellular digestion, that is, with the solution and absorption of foodstuffs from without, thus necessitating exosmosis, or with intracellular modifications, preparatory to the direct use of the substances modified in metabolism or in translocation. Again, the ferments may be present only at a certain definite period in the life of a cell, produced, undoubtedly, by special requirements and special stimulation.

When isolated, or at least when outside of the cell, many enzymes are most active at temperatures far above those which may be maintained within the living cell. An explanation of this fact is difficult. Comparative studies of their reactions to light, heat, toxic agents and other stimuli should be made. In the penetration of parasites, cellulose-dissolving ferments are important, but further information is needed before it can be said that the presence or absence of such enzymes to any great extent affects the resistance of certain varieties and spe-

cies to fungous attacks. It has been stated that the resistance of plants to fungus attacks is due largely to the presence of certain enzymes or toxalbumens present in the cells of the host; and by others it has been suggested that susceptibility is frequently a special property due to the presence of certain oxidases, which are regulated by external conditions.

It has been shown that the mosaic disease of tobacco and other similar diseases are accompanied by certain oxidase ferments which appear to prevent the digestion of reserve food. The ferment is developed in the growing parts of the plant, it may be transferred from plant to plant, and on the decay of the diseased organism, it is supposed to be set free in the soil. It is believed that it is then capable of diosmosis and infection of the young seedling. While it can not be shown at present that the enzyme is beyond all question the direct cause of the disease, this field of work is certainly one which might yield most interesting results. In this connection it may be stated that peach yellows and several other important contagious diseases are believed to be of somewhat similar nature. It is also claimed that the keeping qualities of fruits may bear a certain relation to the amount of enzymes present at the time of storage; and, therefore, a knowledge of the time and conditions of the production of such enzymes would have great economic value.

In general, Czapek found no enzymes to occur in the excretions from the roots of higher plants, and it is now generally believed that the roots of one plant may develop no excretions injurious to neighboring plants, and, therefore, there may be no biological relation between the roots of non-parasitic plants associated in the given plant society. It must be said, however, that the information at hand may not be taken as final. There are yet some peculiar facts with relation to the rotation of crops which may not be readily explained on the grounds of the exhaustion of plant nutrients or of the physical condition of the soil.

The fermentation of tobacco and tea, or hay and manure, involves enzyme actions which in recent times have received some attention, although the problems which are of most physiological importance require solution. The general belief is that in all cases of enzyme action these compounds do not form a part of the substance upon which their action is exerted, but they act as a key in each particular case, unlocking, or rendering labile, a certain organic compound, which is then subject to rearrangement and transformation. This is all, however, too speculative for profitable consideration, although such speculation may have no evil influence if it is not permitted to encourage the reference of all unusual phenomena to an unusually obscure and difficult process.

The early perfection of water culture methods permitted a careful study of the mineral nutrient requirements in the higher plants. Pure culture methods have afforded a more accurate means of studying the needs of fungi and certain algæ. As usually installed, water cultures of the higher plants contain bacteria, so that they afford only a practical test of the requirements. The problem demands some confirmatory tests, at least, under pure culture conditions, particularly when organic compounds are employed. It is possible to grow, in a limited way, higher plants under pure culture conditions.

With the fungi, exact studies may be made upon the influence of the different nutrients on the general form and upon the production of conidia, etc. It has been found, for instance, that, in the absence of

potassium, *Sterigmatocytis niger* may produce no conidia or very curious modifications of the conidiophores. By far the most interesting problems with relation to the mineral nutrients are those which have to do with the rôles of these elements in metabolism. The effect of the lack of one or another element is made manifest by some general macroscopic change, and sooner or later, by disturbing pathological changes and subsequent death. It is reported, for example, that the absence of iron prevents the development of a healthy green color, and a scarcity of potassium is made evident, especially, in reduced photosynthesis.

We are yet merely at the threshold of these problems. A cytological and microchemical study of numerous plants in various conditions of culture is needed. Loew has instituted some good work in this direction. He attempted a careful microscopic study of *Spirogyra* under the conditions indicated. Although well rewarded, he has not followed up the result. The problem is, nevertheless, again under serious investigation, and when much time and thought shall have been devoted to it, with the utilization of the best cytological methods available, important results may be anticipated. The possibilities of the future are particularly dependent upon this, that investigation must be made of all macroscopic changes as well as of all demonstrable microscopic changes.

The interrelations of parasites and hosts, or of symbionts, are of such great physiological interest that some of the most significant problems may not justly be omitted in this connection. It has long been assumed that the conditions of nutrition of a host plant determine to a considerable extent its immunity to parasitic attack. Ward was unable to detect in the bromes any modification of resistance due to either high cultivation or to lack of sufficient mineral nutrients.

The results which have been attained with the Uredinaceæ have established the fact of the existence of 'biologic forms.' This opened a new problem in the study of the Uredinaceæ and it was later ascertained that similar host-restricted forms are present in other groups of the fungi, especially in the powdery mildew *Erysiphe graminis*. Salmon has found bridging host species by means of which the parasite may pass from one species or host to another; for example, the form of *E. graminis* on *Bromus racemosus* is incapable of affecting *B. commutatus*, but does not fail to affect *B. hordeaceus;* and the spores produced on the latter will then affect the previously immune *B. commutatus*. From infection studies it is further found that there are biologic forms among the grass hosts as well. Salmon reports that this restriction of the parasite to certain hosts may be broken down if the vitality of the leaf has been lowered by traumatic means. In this case penetration would result either in the injured area or certainly within the sphere of the traumatic influence. Spores produced by such infections proved capable of infecting uninjured leaves. The application of these results is certainly far-reaching; yet they must be extended and confirmed before a conservative explanation may be advanced. It is undoubtedly more or less in line with the well-known capacity of such fungi as *Botrytis, Nectria* and certain Basidiomycetes to become parasitic under special conditions. Two leading inquiries may be suggested: (1) What constitutes immunity or resistance in the host? (2) What constitutes virulence or attenuation in the parasite?

As the result of practical experiments in cross inoculation, on the one hand, and of close morphological study, on the other,

some investigators have long claimed that there are racial or specific differences between the organisms producing the tubercles on the roots of certain leguminous plants. From the results obtained by Moore (in the U. S. Department of Agriculture) which have been reported, but not yet published, I am permitted to recite a further interesting fact of accommodation. When an organism isolated from one host species is grown for a time artificially, under special conditions of nutrition, its host limitations are in great measure broken down, and it may produce tubercles on a variety of leguminous plants. It is likewise conceivable that in the case of certain yeasts the temperatures at which spores are formed, and the specific fermentative activities, may be changed by special conditions of cultivation.

In view, therefore, of the work already accomplished it is certainly evident that the propriety of basing what are termed species upon certain physiological characters has distinct limitations. I do not intend to bring into this paper a discussion of the inadequacy of the present nomenclature system from a physiological point of view. It may be said, however, that it is scarcely possible for the systematist to consider all physiological characteristics, or to appreciate the confused ideals of the physiologist.

Stimulated by the marked advancement which has been made in physical chemistry, especially in the knowledge of electrolytic dissociation, the past few years have added much to our fund of information with relation to the toxic action upon plants of solutions of both acids and salts, as well also as of certain non-electrolytes. The work of Kahlenberg and True, Heald, Krönig and Paul, Clark and others has contributed enough data for an appreciation of the limitations of toxic action. Nevertheless, no broad generalizations are as yet possible. Indeed, it is not generalizations which are wanted, but further experimental data bearing upon the relation to the toxicity of the ions and molecules and their respective interactions.

Studies may well be made dealing with the relation of nutrition to toxic agents, the effects of temperature and other conditions upon such action, and the accommodation of organisms to increasing strengths of deleterious agents. Naegeli's work on the oligo-dynamic action of copper is beginning to be appreciated and in one way or another the results have in recent times been repeatedly confirmed. In most cases, however, no allowance has been made for the action of the nutrient salts which may be present in the culture fluid and which may affect in a very dissimilar way two different electrolytes. In this connection it is only necessary to call attention to the toxic action of certain compounds of mercury, in which increased toxicity, due to the presence of small amounts of some other salt of the same acid as the mercury salt used, is indeed quite remarkable. Within the past few months an unusually interesting paper has appeared in which Kanda reports the action of certain toxic agents upon plants grown in pots as compared with those plants grown in water cultures. His important conclusions are as follows: (1) A strongly dilute copper sulphate solution, even 0.000,000,249 per cent., is injurious to seedlings of the common garden pea in water cultures; and neither a solution ten times nor one a hundred times more dilute produced any stimulative effect. (2) In pot experiments with soil, the same seedlings are uninjured when watered twice a week during a period of from five to eight weeks with a solution of .249 per cent.; in other words, even after from five to seven grams of copper sulphate were

present in each pot. No explanation is offered of this remarkable diversity of action, but within the past few months another paper has appeared which may throw light upon the results given. True has ascertained that finely divided paraffin, quartz sand, filter paper or other insoluble substances are all found to reduce the toxic action of the deleterious salt. It is explained on the assumption of an absorption of the toxic molecules by the surface of the insoluble particles. Increasing the number of grains of sand, for instance, in any toxic solution produced the same effect as increasing the dilution. From the results of these two papers it would seem, therefore, that we have two entirely different sets of conditions to deal with when any test of such action is made in water cultures, on the one hand, and in soils, on the other. If Kanda's results are confirmed, an extensive series of tests with both fungi and higher plants should be made in order to determine some relation which may give a working basis for further comparisons. In fact, much of the work thus far done will have to be reexamined in the light of these results, for if any precipitate or other solid particles have been present in the solutions, an error will enter into the calculations. The question will also arise if the surface extent of the vessel used in the culture is of any consequence. The practical bearing of these results in the treatment of soils is a matter which may prove of unusual economic interest.

Loew observed that marked injury results when such a plant as *Spirogyra* is placed in a solution of a magnesium salt, or in a solution in which magnesium is in excess. From all of the results obtained Loew has inferred that there is present in all plants requiring calcium an essential calcium protein compound. When magnesium must, owing to the predominance of this element, be substituted for calcium in this proteid compound there results a lessening of the capacity for imbibition, attended by unfavorable consequences. It has been further ascertained by the work of May, Kearney and Cameron, Kusano, Aso and others, that there is for each plant a certain more or less definite relation between calcium and magnesium. Nevertheless, further experimental proof is needed before this brilliant hypothesis may be acceptable in its entirety. It may here be noted that in a paper read by the writer before the Society for Plant Morphology and Physiology it is indicated that magnesium compounds exert upon the marine algæ the least injurious action of all nutrient bases. On the other hand, it has not been demonstrated that the marine algæ require calcium.

The general phenomenon of chemotaxy, or chemotropism, demands searching investigation in view of the recent work of Jennings on flagellates, that of Newcombe on root responses, and other studies on the fungi. There is much to be done in determining the effects of heat and cold upon special processes, in a study of the relations of temperatures to other conditions of the environment, and in showing the limitations of accommodation phenomena. In the latter study, moreover, the effects of accommodation upon the general constitution of the organism should be followed. Stimulation at high or low temperatures merely expresses an intensified or modified irritability. It may be observed in this place that death at the supramaximal or subminimal may be due to changes of a very definite nature; but as Vines has indicated, this means very little. To say that death at the supramaximal is due to the coagulation of an albuminoid as suggested by Kuehne is insufficient. For the immediate effect upon

the protoplasm of this high temperature must also be of consequence. The external conditions of temperature of the effects of a modification of conditions are more or less readily determinable; but it has not been possible to follow the internal changes which result. It may be noted that the freezing point of a plant is lower than that of the expressed sap; yet of course the freezing point is not necessarily a valuable indicator of injury. The effects of temperature upon reproduction will be treated of later.

The symbiotic relationship of fungus and root to *Mycorhiza* offers a fine opportunity for careful investigation. The studies which have already been made serve only to put the reader in a state of hopeless confusion.

The universal phenomenon of irritability as manifested by trophic phenomena has been a fruitful field of investigation. The general methods of irritable response have been determined; and the best work of such investigators as Haberlandt, Noll, Czapek, Newcombe, MacDougal and others has more recently been directed to the deeper problems relating to the internal mechanism of response and to the exact methods of transmission of the stimulus, as well as to the immediate changes in the cells affected.

A word may be said concerning the regeneration phenomena which are strikingly characteristic of the lower groups of plants, but which in the higher plants do not seem to be well emphasized, and are certainly less understood. The regeneration of the root tip has been best studied. In none of the higher plants has it been possible from a single isolated active non-sexual cell, or a small group of cells, to regenerate the plant.

Although a study of the physiology of reproduction may be said to have had its origin in the early observations of Camerarius, all early studies represented largely only the ecological aspect of the subject. It is only in very recent years that rapid strides have been made in the general physiology of reproduction. The effect of conditions upon the production of antheridial or archegonial thalli or of pistillate or staminate flowers among diœcious and polygamous plants has received very slight attention. During the present year Laurent has published the results of experimentation during a period of seven years with the effects of fertilizers, or plant nutrients, upon spinach, hemp and *Mercurialias annua*. It will be seen that according to his results an excess of nitrogen or calcium has a tendency to produce staminate flowers in the spinach, while potassium or phosphorus tends to increase the production of pistillate flowers. The seed produced on the pistillate flowers of these plants gave a preponderance of female plants; but from these plants, in turn, the seed yielded a larger number of staminate plants. So far as I have been able to learn, it has never been determined if in a case of diœcious perennial plants it is possible by a change of conditions to induce a temporary or permanent change from pistillate to staminate flowers, or *vice versa*. In the same way, the influence of grafting or budding a scion of one upon the other has not been made out, although it is assumed that the flower will be characteristic of the scion.

It is with reference to the effects of external conditions upon the production of sexual and asexual fruiting organs that unusual progress has been made. In this direction a field of great magnitude has been opened by the work of Klebs, and it is evidently being pursued along all possible lines. As yet this work has been extended only to a few green algæ (as, for example,

Hydrodictyon and *Vaucheria*); several fungi (*Sporodinia grandis* and *Saprolegnia mixta* especially); certain yeasts and bacteria, and finally, to several species of phanerogams. While with the algæ the light relation is of prevailing importance, with the fungi it is more particularly a matter of nutrition or transpiration. As a rule, with the latter Klebs finds the stimulus to reproduction in the failure of the food supply in the immediate vicinity of growth. That is, beginning with a well nourished mycelium a diminution of food supply, other conditions being constant, usually compels reproduction. A change in the specific chemical content may be effective, and in other cases there are other concurrent stimuli. In the study of phanerogams it would seem that the problem is one which is, as a rule, far more complex. It has, however, been found possible with a few species to produce at will continuous vegetative growth or continuous flowering, to induce fruiting in a well nourished vegetative shoot, and to incite vegetative growth in a flowering axis. It is probable that all shades of difference will be found in the capability of plants to have these processes distinguished by releasing stimuli; and it remains for the future to determine to what extent this is possible.

The general law which seems to be warranted is, that conditions most favorable for growth do not favor reproduction. The problem then is to determine for every organism what are these conditions under which, on the one side, growth, and on the other, reproduction, may occur. Whether, under any circumstances the complete cycle of development may be run without any change in conditions apparently awaits proof.

In grafting it would seem that seldom, if ever, do any characters of the stock pass into those of the scion except such characters as may be due to the presence of diffusible metabolic products, or products capable of self-propagation upon requisite stimulation. In this manner it has been shown that albinism may be transmitted from stock to scion. Again, Strasburger has indicated that atropin is accumulated in the potato when on a potato stock there is grafted a scion of *Datura stramonium*. It has been found that hardiness in the stock may affect the scion to a marked degree, but here the real problem is to determine what constitutes hardiness.

Fusion possibilities in vegetative cells are more or less common in all groups of plants. In basidiomycetes parallel filaments fuse under many conditions of development, and a pseudoparenchymatous tissue may result. In grafting, the layers which fuse may represent different species or even different genera. Little is known concerning the factors influencing such fusions. Allusion may also be made to the fact that plasmodia of the same species of myxomycetes (at least when produced in nearly similar conditions) fuse with one another. It should be accurately determined if this is an inherent property of the same race or species only, and if this fusion tendency may be weakened or dissipated by diversity of conditions under which the plants may be grown. The solution of such problems with simple and rapidly culturable organisms may even throw some light upon the more complex problems of self sterility and prepotence (in the sense in which these terms are used horticulturally) in higher plants—phenomena which may not be explained with present information. It has been found that tomato and tobacco fruits are sometimes formed without pollination; and the same is true of other plants. In certain cucurbits the act of pollination seems to afford a stimulus for the development of

the fruit, even the dead pollen serving to call forth this response. Under such circumstances it may well be that other chemical stimuli may produce the same effect. On the whole, there are no more interesting problems in physiology than those relating to pollination, the penetration of the pollen tube, and conditions of fertilization. Many phases of these problems have thus far been studied by gardeners and horticulturists alone.

In this connection may be mentioned another fusion phenomenon of physiological interest—that of double fertilization in the angiosperms. This fusion of the second sperm nucleus with the endosperm nucleus (itself a compound of two nuclei of the gametic groups) or with one of the polar nuclei, may have a special significance, or it may be merely the expression of the fusion tendency which has not been lost, although the function of the endosperm nucleus may have undergone specialization. In the case of the pine, it will be remembered that the second sperm nucleus frequently undergoes division in the cytoplasm of the egg. What is meant by the fusion of the gametes? This is always a fundamental problem. It may be strictly a matter of the fusion of characters, or it may further be a stimulus to embryonic growth. It is a remarkable fact, however, that this stimulus to embryonic growth does not merely involve the embryo itself. The limitations of the correlations which seem to exist between the mere process of fertilization and incitation to growth in the extra-carpellary structures are extremely complex. On the other hand, the process of fusion is often immediately followed by the resting period.

It would be extremely well if further attention could be directed to the matter of parthenogenesis in the higher plants. Except in the case of Nathanson's studies upon Marsilia, little has been done to indicate the conditions which may induce or which may tend to induce this process. In recent years, artificial fertilization, or stimulus to a certain growth of the egg in the lower animals, has been effected by chemical agents, by changes in the density of the solution, and by other means. This work has demanded world-wide attention from animal physiologists. It has been too much neglected from a botanical point of view, although the difficulties involved in similar studies with plants would be, for the most part, immeasurably greater. Yet it is certainly possible to prosecute such studies along the lines indicated.

Except in the case of *Sporodinia grandis*, and perhaps one or two other species of Mucoraceæ, mycologists have experienced great difficulty in securing the zygosporic stage of these fungi. The recent paper by Blakeslee, announcing the conditions governing zygosporic formation in this family, seems to open a field for investigation wholly novel and suggestive. The substance of his results is that this family may be divided into two principal categories, designated, respectively, as homothallic and hetereothallic, these terms corresponding to monoecious and dioecious forms among higher plants. *Sporodinia grandis* belongs to the homothallic type, both gametes in every union developing from the same thallus. *Rhizopus nigricans* belongs to the second and larger class, the hetereothallic type, in which the two gametes are invariably the product of two mycelia, which mycelia are sometimes of diverse vigor. When in culture, the two strains, as they are termed, grow together, zygospores are abundantly produced along the lines of contact. These are the striking results of this important paper; but other related physiological facts have been observed, and only further investigation can

tell whether this is a special case of gametic union in the fungi, or whether similar phenomena may be found to be characteristic of other groups where there is gametic union.

The discovery of Mendel's hybridization studies and the independent confirmatory evidence furnished by de Vries, Correns and others all indicate the necessity of differentiating unit characters and of following separately the inheritance of each unit character. The idea which it involves of the purity of the gametes with respect to unit characters, the segregation of unit characters in the formation of the gametes, is one of fundamental importance. Such work has given a marvelous impetus to studies in inheritance. Numerous investigators have followed up this work, but it will be many years, perhaps, before a test of the Mendelian laws can be carefully made with any great number of plants and animals. The exceptional instances already reported of the appearance of mosaic characters and the dissimilarity in the product of reciprocal crosses themselves indicate further fields for experimental research. Only a word need be said bearing upon the phylogenetic side of physiological work, since phylogeny, as well as pathology or ecology, constitutes a separate section of biological science. The admirable work accomplished by de Vries, serving beyond all question to demonstrate experimentally the origin of species by leaps or mutations, necessitates laying further stress upon discontinuous variation as a factor in the origination of existing species of plants. It is to be doubted, however, that most botanists will at present concur in such an opinion as that the evidence advanced is sufficient to disregard or disparage the part which is played by continuous variation in the origination of species. Continuous variation must be manifest by relatively slight variations; and it would be unfair to expect at this time the experimental proof of its efficiency. It may even be assumed that there is a complete series between continuous variations and discontinuous variations, as well, perhaps, as between the possibilities of inheriting immediately or ultimately such variations. Many of the problems in plant physiology are distinctly practical problems. The task of the physiologist is primarily to study the activities of plants irrespective of practical bearing. To have the greatest possible breadth and force, however, the cultivated plant may not be neglected in any of its artificial environmental conditions. It is unfortunate that as yet physiological botany has not been made fundamental to agronomy, horticulture, forestry and other sciences, arts or commercial pursuits. Physiology can not be limited by any practical problems, nor can any sacrifices be made, but a sympathy with commercial endeavor will invigorate the work, will afford equipment and will contribute towards the common good.

In conclusion, it may be said that present-day physiology, even more than any other section of biological science, is fundamental. Many phases of pathology, ecology, phylogeny and experimental morphology, especially, may not be clearly differentiated as sections. Broadly conceived, plant physiology concerns itself:

1. With the relationships of existing organisms, ontogenetically and phylogenetically. Phylogeny would necessarily claim much of this general field, as would also morphology, ecology and other subdivisions.

2. With the functions or activities of organs, tissues and cells, and the interactions and interrelations of these one with another and with external forces. It is here that morphology touches physiology

most closely and here experimental morphology must have its basis.

3. With the incorporation and excretion of matter, metabolism and growth, the sources and uses of energy, irritability, and the minute constitution of living matter. In this last are included many of the most fundamental problems, not necessarily problems involving the question 'What is life?' but problems concerned with the resolution of those factors and an intimate knowledge of those materials which make life possible.

BENJAMIN M. DUGGAR.

SCIENTIFIC BOOKS.

THE BAHAMA ISLANDS.*

This handsome volume on the Bahama Islands is of merit in two regards. It is an appropriate expression of the energetic initiative of its editor in developing an interest in geography in Baltimore, and it is a serious scientific study of a peculiar group of islands.

Professor Shattuck offered a course of lectures on physical geography to the teachers of Baltimore several years ago. The course proved attractive and was well attended; it was followed by an association of the teachers for more lectures and for field excursions under Shattuck's guidance. This association was soon succeeded by the organization of the Geographical Society of Baltimore under the presidency of D. C. Gilman and the direction of a distinguished board of trustees. The membership in the society rose to something like 1,500 in its first year of existence. Its objects were to place before the public of Baltimore an annual course of lectures dealing with geographical subjects, to foster geographical research, and from time to time to publish monographs of geographical investigations. All these objects have now been realized; hence although the activity of the society has been sadly interfered with during the past year by the disastrous conflagration of 1904, the secretary, as director and editor of the Bahama expedition, has had so notable a success in bringing out a monographic volume on the first investigation undertaken by the society that we confidently expect a revival to full activity in due time, and a vigorous continuation of the work thus begun.

Shattuck having made a preliminary visit to the Bahamas in 1902, the expedition of over twenty members left Baltimore June 1, 1903, in the *Van Name,* a hundred-ton schooner, provisioned for a two-months' cruise, and with an equipment to which the governmental bureaus at Washington and the Johns Hopkins University had contributed. The results of the expedition are now set forth in sixteen chapters by nearly as many authors. Shattuck and Miller describe the geology and physiography of the islands; Dall discusses the fossils and the non-marine mollusks; Fassig reports on magnetic and climatic observations, and Shidy on tides. The soils are elaborately classified by Mooney; Coker describes the vegetation, and Coffin tells of the mosquitoes. The fishes, birds, reptiles and mammals are reported on by Bean, Stejneger, Riley and Miller; the sanitary conditions by Penrose. The longest chapter is a history of the islands by Wright, and the volume closes with some general geographical considerations by Shattuck. The illustrations are numerous and good.

Earlier observers have shown that the Bahamas consist of 29 islands, some of which are mere skeletons or strips of land, with numerous small keys and rocks, in all some three thousand in number, rising from a shallow submarine platform or plateau, which in turn stands up rather abruptly from the deep ocean floor. The material of the platform as far as known and of all the islands is altogether calcareous, of shell and coral origin, worked over by waves and winds. On the islands the rock is weathered into a ragged and pitted surface; its texture is so weak that it is sawed or chopped into blocks for house building. The area of the islands is but a fraction of that of the platform, partly be-

* The Geographical Society of Baltimore. The Bahama Islands. Edited by George Burbank Shattuck, Ph.D., associate professor of physiographic geology in the Johns Hopkins University. New York, Macmillan. 1905. 630 pages, 93 plates, 7 figures.

cause of submergence from a time of a more continuous land surface, partly because of shore erosion, which goes on furiously during autumnal hurricanes. The submergence is inferred to have amounted to 300 feet, because the islands are honeycombed with caverns, of which the deeper ones descend 300 feet beneath present sea level.* Observations by the geologists of the expedition indicate that the submergence of the islands has recently been somewhat greater than now, for stratified deposits containing fossils of living marine species are found at altitudes of fifteen or twenty feet at many places. Whether the islands are now rising or sinking is not asserted, but the bench marks that were set up and carefully measured with respect to sea level will make it possible to answer this question within a few score years.

The shallower parts of the submarine platform are so thickly studded over with coral reefs that it has proved impracticable to chart them. At certain points the platform is pierced with 'ocean holes,' or areas of deep blue water in the midst of the shallower green sea. Here the tide ebbs and flows through sub-platform passages; in one instance that is described a descending eddy was noted, with concave surface and foaming center. The tides were carefully observed at Nassau and thus better determined than ever before for these islands; they are shown to be of the Atlantic type, that is, with two subequal high tides in each lunar day; and not of the Gulf type, in which, as a rule, only one tide occurs each day. The mean tidal range is 2.634 feet, with spring and neap means of 3.051 and 2.129 feet; the mean lunitidal interval or corrected establishment of the port is 7 h. 22.8 m.; but the variation of this interval due to priming and lagging may amount to 45 minutes. The well-known uniformity of the Bahaman climate is attested; even in early summer, temperatures of 80° or 90° were not oppressive, the air being moderately dry and usually in motion. Flights of kites and observations on clouds indicated a diminution in the velocity of the prevailing easterly trade wind above 4,000 feet altitude, a curious contrast to the conditions obtaining in temperate latitudes where an increase of velocity with height is the rule.

The soils of the islands are described in greater variety than one might expect on a foundation exclusively calcareous, seven types being recognized. The most important are the black loam and the red loam. The former occupies about three fourths of the surface, and makes what is known as 'provision land,' because of its use for subsistence crops. It is good for citrus fruits, among which the shaddock or grape fruit takes the lead; but this soil is so thin that when fruit trees are planted, a hole is first blasted in the underlying rock. Sisal, which is destined to be an important product, and cotton, more important formerly than now, also grow in this soil; the cotton plant grows tree-like, living over several seasons and having to be pruned to keep its branches within reach. The red loam soil is the best for pineapples, a very important crop, as over seven million dozens were exported in 1902, yielding almost $200,000; but the prices have fallen in recent years, partly on account of the poor treatment of the pineapple in marketing it. The receipts from this source are at present much exceeded by those from sponges.

We shall pass rapidly over the biological chapters. There is an elaborate list of plants,

* This line of argument is in accord with current geological opinion, yet it does not appear to be altogether proved that submarine caverns may not be dissolved out by fresh-water streams which descend beneath the level of the sea and rise again to the sea floor; just as caverns are conceivably formed beneath the level of the ground-water table on the land. Many land caverns now above the water table are filling with calcareous deposits; the excavation of such caverns by solution may have taken place before the neighboring valleys were worn to their present depth, or when the region stood at a lower level, so that the cavern zone was beneath the water table, and the growing cavern was filled with water. Whether the cavern zone was beneath the land or beneath the littoral sea floor is immaterial, so long as the ground water is kept in motion. Is it not indeed possible that the excavation of some submarine caverns was begun as well as continued by the tidal currents now flowing through them?

950 species of native and naturalized forms being noted, including seven indigenous palms, several figs and thirty orchids. Many species are shared with the United States, but most of our deciduous forest trees are wanting. The important geographical element of distance shows its effect in the less number of continental plants in the southern than in the northern islands. Although the yellow fever mosquito was found, thus making a properly screened quarantine desirable at Nassau, the absence of *Anopheles* indicates that, from the standpoint of malarial diseases, the islands are a good health resort; on a later page, the islands are described as favorable for consumptive cases also. The only marine forms described in detail are fishes; these are noted as having a popular interest for the tourist because of their extraordinary colors and forms, well seen when watched through the floor of a glass-bottomed boat. Of reptiles and batrachians, no less than 22 out of 35 species and subspecies are restricted to the islands. Forty-four endemic species of birds, out of a total of 204 species and subspecies, are described in detail in their bearing on the derivation of the Bahaman avifauna. Only eight mammals are found whose presence is not certainly due to man; these include rats, mice, the rat-like hutia, raccoons and bats.

The chapter on sanitary conditions is of unusual and pitiful interest. Some of the islands have only white inhabitants; some have nearly all blacks; others are variously mixed as to race. The island of New Providence, on which Nassau is situated, has a well-civilized mixed population; the island of Andros, the largest of the group, has a relatively barbarous population of blacks. The islands of only white population have many degenerates. At Hopetown there has been an excessive amount of intermarriage, and although the original stock was good, the present condition is deplorable, the climax being found in a family of eight children, of whom five are idiots. An instructive genealogical tree is given in connection with this case. Leprosy is not uncommon, but except at Nassau there is no isolation of those suffering from this dread disease. The expedition was provided with an excellent medical outfit, and at each town a free dispensary was established during the stay there. The people were timid at first, but after gaining confidence they came in throngs; when the party had to return to the schooner, it was with difficulty that the outfit was packed up, and a way forced through the crowd; the more determined invalids followed on boats, climbed on board the schooner and begged to be cared for. A special account is given of the most important diseases met with.

The chapter on the history of the islands is a book of 160 pages in itself. After brief description of the early buccaneering days, special attention is given to the problems of slavery, with sufficient indication of the wretched treatment that too often occurred, and little illustration of the obsolete argument that the conditions of the blacks was then better than under freedom. Yet to-day the condition of the people must certainly be low, for one of the governors, recently appointed by the crown, thinks that there is not enough good material in the islands to provide the twenty-nine members of the legislature which is to share the government with him. "What is wanted here," says the governor, "is a system based on that so ably conducted by Mr. Booker Washington, at Tuskegee, Alabama, United States of America, and until that or some similar scheme based upon industrial training as the main factor in the educational method is adopted, I fear that no improvement in the condition of the large native population in this colony will be manifested." In view of all this, one must conclude that the islands, with their mild and attractive climate and the beauty of their oceanic setting, must, nevertheless, be taken as illustrating the unfortunate and depressing consequences of monotony and isolation.

W. M. D.

SOCIETIES AND ACADEMIES.

THE PHILOSOPHICAL SOCIETY OF WASHINGTON.

THE 602d meeting was held May 13, 1905.

Mr. L. W. Austin read a paper on 'The Specific Heat of Gases at High Temperatures,' describing experiments made by Professor Hol-

born and himself at the Physikalisch-Technische Reichsanstalt during the years 1903–04, with the object of bridging the gap in our knowledge of the specific heat of gases between 200° and 1000°. Below 200° we have the experiments of Regnault and others, while between 1000° and 2000° we have the explosion experiments. Regnault and his co-workers found the specific heats of the simple gases independent of temperature, while Mallard and Le Chatelier have concluded that the specific heats increase with temperature. The method of mixtures at constant pressure was employed, the gases being heated in an electrically heated nickel tube filled with nickel filings, according to the method of Wiedemann, and the heat being taken up in the calorimeter by small silver tubes filled with silver filings. The temperature of the hot gases was measured by a platinum/platinum-rhodium thermoelement at the point where the gases entered the calorimeter. After leaving the calorimeter the gases were caught in a gasometer at atmospheric pressure, the volume being measured by means of the displaced water. The gases did not come into direct contact with the water but were caught in a rubber bag, so experiments were possible with the more easily absorbed gases. In Table I. the results for the simple gases, and oxygen, nitrogen and air, are given. These indicate an increase in the specific heat of about three per cent. for air and nitrogen between 20°–440° and 20°–800°. However, as the limit of accuracy is hardly better than ± 1 per cent. the observed difference but little exceeds the possible errors of observation. The results for carbon dioxide are given in Table II. compared with those of Regnault, Wiedemann, Mallard and Le Chatelier, and Langen.

Table I.

Between.	N.	O.	Air.
10–200°	(0.2438)*	(0.2175)*	(0.2375)*
20–440°	0.2419	0.2240	0.2366
20–630°	0.2464	0.2300	0.2429
20–800°	0.2497		0.2430

Table II.

	Regnault.	Wiedemann.	Mallard and Le Chatelier.	Langen.	Holborn and Austin.
0°	0.1870	0.1952	0.1880	0.1980	0.2028
100°	0.2145	0.2169	0.2140	0.2100	0.2161
200°	0.2396	0.2387	0.2390	0.2220	0.2285
400°			0.2840	0.2450	0.2502
600°			0.3230	0.2690	0.2678
800°			0.3550	0.2920	0.2815

* From Regnault.

Mr. A. L. Day described 'An Interesting Pseudosolid.' It was a fine foam made of Plateau's solution or white of egg and sugar. Cylinders cut from this showed elastic properties like a solid but through a wider range and a fracture, photographs of which appeared like marble fractures. Since the dimensions of the cylinder under stress could not be measured directly photographs were used; the results were consistent to one half per cent. Poisson's ratio came out nearly .50. He also detailed the results of experiments on 'The Linear Force of Growing Crystals.' Thus, an alum crystal raised a weight of 1 kg. per sq. cm. through several tenths of a millimeter; the growth takes place only at the lower edges and the area of the supporting edge is too small to measure with accuracy; the forces are of the order of other molecular forces, and are quite sufficient to produce and enlarge fissures in the rocks. Both investigations have important bearings in geology.

President Littlehales then read a biographical sketch of the late David Smith, chief engineer in the navy (1834–1903); his most notable services were in standardizing naval equipment and in improving the ventilation of ships.

Charles K. Wead,
Secretary.

The Science Club of the University of Wisconsin.

The eighth meeting of the club for the year 1904–5 was held on Thursday, May 18, at 7:30 P.M., in the physical lecture room, Science Hall.

The first paper of the evening, by Professor J. L. Bartlett, dealt with the subject, 'The Influence of the Madison Lakes on Local Air Temperatures.' The speaker showed that

through the influence of the lakes, which cover one third of the total area within a radius of six miles from the university, the growing season at Madison is appreciably lengthened. It was shown by comparisons with the average data for four neighboring stations, which have strictly continental temperature conditions, that there is an average departure from local continental types of from 0 to −3 degrees in the mean maximum temperature during the various months of the year, of 0 to +4 degrees in the mean minimum temperature, and an increase in summer and autumn in the mean monthly temperature, and a decrease in spring.

The subject of the second paper of the evening, by Professor C. S. Slichter, was 'The Underflow of the Arkansas River.' The speaker presented the results of an investigation conducted last summer under the auspices of the United States Reclamation Service of the region covering the drainage basin of the Arkansas River from Garden, Kans., westward to the state line. The work done indicates that the water of the Arkansas underflow has its origin in the rainfall upon the sand hills to the south of the river and upon the bottom lands and plains to the north of the river. The rate of movement of the underflow was found by the electrical method to vary between eight and eleven feet for twenty-four hours. It was shown that the Arkansas River contributes water to the underflow in time of flood. When the river was high a movement of the ground water away from the river channel was measured and found to be about eight feet for twenty-four hours.

The following members were elected officers of the club for the year 1905–6:

President—Professor Louis Kahlenberg.
Vice-President—Professor C. K. Leith.
Secretary-Treasurer—Professor Richard Fischer.

F. W. WOLL,
Secretary.

THE SAN FRANCISCO BIOLOGICAL CLUB.

A MEETING of the recently organized San Francisco Biological Club was held on April 22, 1905. The following papers were presented:

PRESIDENT DAVID STARR JORDAN: 'Actual Origin of Species.'

PROFESSOR JACQUES LOEB: 'On Artificial Parthenogenesis.'

PROFESSOR G. J. PEIRCE: 'Irritability in Algæ.'

PROFESSOR J. B. MACCALLUM: 'On the Diuretic Action of Certain Hæmolytics.'

DR. F. W. BANCROFT: 'On the Validity of Pflüger's Law for the Galvanotropic Reactions of Paramœcium.'

DR. P. OLSSON-SEFFER: 'Seed-transport by Oceanic Currents.'

DR. HAROLD HEATH: 'The Development and Significance of the Body-cavity in Certain Invertebrates.'

PROFESSOR J. C. MERRIAM: 'Adaptive Radiation in the Early Reptilia.'

PROFESSOR C. A. KOFOID: 'On the Structure of some Pelagic Ciliata.'

PROFESSOR W. A. SETCHELL: 'Regeneration in Kelps.'

PROFESSOR W. J. V. OSTERHOUT: 'Polarity in Plants.'

W. J. V. OSTERHOUT,
Secretary.

THE PSYCHOLOGICAL CLUB OF CORNELL UNIVERSITY.

THE session of 1905 has been devoted to the consideration of experimental studies of memory and economical learning. The following papers have been read:

PROFESSOR TITCHENER (two papers): 'The Work of Ebbinghaus.'

PROFESSOR BENTLEY (two papers): 'The Work of Mueller and Schumann.'

MR. H. C. STEVENS (two papers): 'The Work of Mueller and Pilzecker.'

MISS E. MURRAY: 'The Importance of Repetition.'

MR. J. H. COFFIN: 'Learning by Whole and Part.'

DR. T. DE LAGUNA: 'The Distribution of Repetitions.'

MR. R. B. WAUGH: 'Economy of Learning, I.'

MR. S. P. HAYES: 'Economy of Learning, II.'

MR. A. C. MUHSE: 'Economy of Learning, III.'

MR. G. H. SABINE: 'The Trend of Investigation: Problems and Methods.'

DISCUSSION AND CORRESPONDENCE.

AN AUTOMATIC CATALOGUE OF SCIENTIFIC LITERATURE.

To the Editor of Science: The cataloguing of current scientific literature is receiving considerable attention at the present time. The difficulty of accomplishing this with promptness and completeness is well shown in the first annual issue of the 'International Catalogue of Scientific Literature' comprehensively reviewed by Professor H. B. Ward, in a recent number of Science.

The spectacle of four organizations employed in practically the same work, viz., the cataloguing of zoological literature, and all the catalogues found to be incomplete when carefully scrutinized in any particular line, would seem to demonstrate the futility of hopes for a complete catalogue in a system where the cataloguers are compelled to collect and review the literature.

For a catalogue of scientific literature to be of great value it should enable a writer to feel that justice has been done his predecessors when the literature catalogued under any subject in question has been canvassed, and this will not be the case if there is even a doubt as to completeness. On the other hand, a catalogue, in which confidence was justified, would save an enormous amount of labor and greatly increase the efficiency of the world's investigators.

The character of the publications in which the results of scientific work appear are so diverse and difficult of access, and the amount of literature to be catalogued is really so large that any approach to absolute completeness by the means now employed seems out of the question, even with the most liberally endowed organization.

It seems clear to the writer, at least, that the desired result can be obtained only by some scheme in which the authors themselves are responsible for the cataloguing.

In scientific work the class that writes is, to a large extent, the same as that which consults the literature and it would seem only just that those wishing to use the work of others should be willing to make their own work accessible. Scientific etiquette now demands that articles be published under reasonably short and appropriate titles, thus assisting the cataloguers in their enormous undertaking. May it not be possible to carry this a step further?

Let it be considered a necessary part of the publication of an article, that the title, at least, and an abstract, if desired, be submitted to the cataloguing organization. The labor of that body would then be confined to editorial work and could be accomplished by a comparatively small staff. The abstracts would convey the ideas of the authors and the interest which every writer takes in his own work would insure the completeness of the catalogue. It would be necessary to establish a maximum ratio between the length of the article and the length of the abstract. The general classification of the subjects would need to be made public and the authors should indicate under which branch they wish their work to be catalogued, it being allowable to catalogue a title under more than one subject-head with cross-references to the place where the abstract appears.

The title and abstract should be submitted simultaneously with the appearance of the publication; thus the catalogue could be complete to date of issue. This feature would also be entirely automatic, as it would be to every author's advantage to have his work placed before the public as promptly as possible.

Any scheme of this kind will appear to many as fanciful. Whether this charge be just or not depends entirely on the way in which the scheme is launched.

If simultaneously adopted by the large scientific organizations its automatic nature would insure its success. If put into operation prematurely by any organization that does not command the support of the scientific public its failure is no less certain. Indeed, an attempt of similar nature was made not long since by an obscure institution whose prospectus received little or no attention, other than that aroused by the fantastic English in which it was couched.

G. N. Collins.

U. S. Department of Agriculture.

'LIFE AND CHEMISTRY.'

TO THE EDITOR OF SCIENCE: The interesting address of Professor Charles Baskerville, entitled 'Life and Chemistry,' published in SCIENCE, Vol. XXI., No. 539, contains a statement which calls for review. He says that "Seed, one of the means of nature's reproduction, may remain years, centuries, in vaults, as within the Egyptian pyramids. When subjected to the proper conditions, they sprout and reproduce." What are the 'proper conditions' for the germination of these mummy seeds? DeCandolle, and others, experimented with seeds in many ways, and were unable to prove that they possessed such remarkable longevity as that referred to in Professor Baskerville's address. Their germinating experiments indicated that few seeds retained their 'vitality' after ten to fifteen years. They appeared to believe that thirty years was the limit of longevity in the most vigorous seeds.

Seeds collected from mummy cases, and reported to have germinated, are regarded by many botanists as 'salted.' This view regarding the short longevity of seeds is current in botanical literature. If that literature is incorrect it should be revised.

M. A. BRANNON.

SPECIAL ARTICLES.

THE IDEAS AND TERMS OF MODERN PHILOSOPHICAL ANATOMY.*

THE ideas of philosophical anatomy have been developed during three periods of human thought: First, the Greek, in which adaptation was clearly perceived as the central phenomenon of life, in its morphological and physiological expression. Second, the pre-Darwinian period, in which ideas of the environmental relations were developed especially by Bacon; and various forms of morphological, physiological and especially psychical adaptation were developed gradually through the studies of Buffon, Lamarck, Geoffroy, St. Hilaire and more especially Goethe; adaptations began to be distinguished broadly into *primary*, or those which had been of use in past time, and *secondary*, or those which were recent in origin and in full use at the present time. Even prior to these writers, however, Vesalius in his studies of human anatomy perceived the importance of this distinction. Philosophical anatomy really owes to Darwin himself the fundamental ideas which are involved in the terms primitive, retrogressive, progressive and dominant, and are now understood with perfect clearness. This is the third period of anatomy as established on evolution. Huxley in his brilliant essay of 1880 on 'The Laws of Evolution as Applied to the Mammalia' was the first to emphasize persistent primitive characters and modernized or adaptive characters, laying great stress on the importance of the former in questions of phylogeny. Among many other anatomical papers E. Ray Lankester's 'Degeneration, a Chapter in Darwinism,' brought out especially the significance of retrogressive changes.

Huxley was a master of logic, but even his keen vision failed to recognize the vast importance of the element of analogy, or similarity of function, in bringing about a similarity of structure in evolution independent of real similarity of kinship. This final phase broad extension of paleontology, and the demonstration over and over again in nature that similar forms have been produced independently either by parallelism from animals related in ancestry, or by convergence in animals unrelated in ancestry. To these processes and results of similar modeling Lankester has applied the fitting terms homoplasy and homoplastic.

In the table an attempt is made, for the first time to my knowledge, to bring together all these processes of change and to indicate their interrelations. There can be little disagreement as to the terms in columns I., II., III., but some surprise may be felt as to the broad inclusiveness of column IV. The justification for this column lies in the fact that in the analysis of any animal form the questions which each anatomist should put to himself as regards each character are: Is this a primi-

* Presented before the New York Academy of Sciences, by Henry Fairfield Osborn, April 10, 1905.

THE IDEAS AND TERMS OF PHILOSOPHICAL ANATOMY.

I.	II.	III.	IV.	V.
			COMPARISON.	
Life is the continuous adjustment of internal and external factors and processes. Adaptation is of the broadest character and relations, internal and external, including:		In every animal adaptations of the past, present and future mingle, and may be broadly distinguished into:	AS REGARDS PRESENT TIME. Animal and plant types, organs and functions are accordingly found in all grades of development and adaptiveness, with reference to past, present and future activity.	AS REGARDS ORIGIN. The results of adaptation in different animals and plants are also comparative, *i. e.*, similar, or dissimilar, according to the operation of similar internal (*i. e.*, hereditary) and environmental conditions.
ENVIRONMENTAL OR BIONOMIC, *i. e.*, in relation to physical and living surroundings, to geologic, geographic, physiographic, meteorologic, faunal and floral conditions or changes.	ADAPTATION AND ADAPTABILITY.	PRIMARY OR PRIMITIVE.	1. *Primitive.* 'Persistent primitive,' or arrested types, organs and structures which continue to be useful although perhaps of very great antiquity, resulting from the balanced or stationary, also 'progressive' and 'retrogressive' condition.	I. HOMOLOGOUS, *i. e.*, *Homogenous.*
MORPHOLOGICAL OR ANATOMICAL, *i. e.*, structural, in organs, direct or correlated.		SECONDARY OR ADAPTIVE.	2. *Retrogressive.* Declining types, organs, habits and functions. Reduced, degenerating, partly functional, and functionless, passing through the stages of 'regressional,' 'vestigial,' 'variable,' 'atavistic,' or 'reversional' (according to certain percentages of occurrence) into 'recessive' (*i. e.*, very rarely reversional).	II. ANALOGOUS. *Parallel.* Analogous adaptations, *i. e.*, similar characters arising independently in *similar or related animals or organs*, causing a similar evolution, and resulting in parallelisms.
PHYSIOLOGICAL OR FUNCTIONAL, *i. e.*, in habits and uses of organs.			3. *Progressive.* Rising or developing types, habits, organs and functions. Rudimentary, prophetic or nascent organs and structures in the true sense of beginning, becoming sub-functional, then functional or fully useful.	*Convergent.* Similar adaptations arising independently in *dissimilar or unrelated animals or organs*, causing a secondary similarity or approximation of type, resulting in *convergence.*
PSYCHICAL AND NEUROLOGICAL in the brain, nervous system, and psychic life generally, imitations, instincts, intelligence.			4. *Dominant.* Organs, etc., attaining such importance as to overshadow all others, often leading to the extinction of the types through extreme specialization.	III. NON-ANALOGOUS. *Divergent.* Increasing specialization and differentiation resulting in 'divergence' or 'adaptive radiation.'
		TRANSITIONAL.	1. *Modifications.* Somatic changes, environmental, also use and disuse, in part germinal.	
			2. *Fluctuations.* Germinal, fluctuating changes of degree, continuous.	
			3. *Saltations.* Germinal, marked changes of kind, sports, mutations of De Vries, discontinuous variations.	
			4. *Rectigradations.* Continuous germinal changes in a single direction, mutations of Waagen.	
	The collective phenomena of fitness and the evolution of fitness as the essential and distinctive feature of life.	Fitness in time, *i. e.*, in past time, in the present, and tending toward fitness in the future.	Grades or degrees of fitness as determined in *individuals* by direct study or comparison, in the sciences of anatomy, comparative anatomy, paleontology, embryology, in ontogeny, fetal and larval life.	Fitness of certain groups or organs in comparison with *other groups* (*i. e.*, classes, orders, families, genera, species, varieties) as well as in comparison with organs and functions in other groups of animals.

tive or a secondary character? If primitive, is it in a balanced or stationary condition, or is it in process of change? Secondly, is this a retrogressive or a progressive character? Questions to be answered certainly only by the evidence afforded by ontogeny or paleontology, and in a comparatively limited number of cases by comparative anatomy. Further, it may be necessary to ask: Is this a dominant character, or one which has attained such importance in evolution as to crowd out and overshadow all others?

Anatomical analysis, however, does not stop here; we must constantly be on the lookout for transitional characters or characters in the very act of change. These transitional or evolutional characters appear at present to be of four kinds: first, *modifications,* or such as have been brought about during the life of the individual without necessarily being connected with germinal changes; second, *fluctuations,* or fluctuating variations, changes of degree or proportion which may be due either to somatic or to germinal causes, one of the most difficult problems in regard to fluctuations being to ascertain how much is germinal and how much is purely somatic; third, *saltations,* which are altogether germinal, or at least prenatal, in origin, including marked changes of kind, the 'sports' of Darwin and Galton, the 'discontinuous variations' of Bateson, and the 'mutations' of de Vries. Wide celebrity has been given to the word 'mutation' through the brilliant experiments and observations of de Vries, but the original significance of this term as employed by Waagen and Scott was a different one, and I think it probable that Waagen used it in the sense of determinate variation. Fourth, *rectigradation,* a new term with which I propose to characterize what in the year 1889 I described as 'definite variations'; it embraces changes which many writers have described as 'orthogenetic,' under the supposed law of direct change, usually in an adaptive direction, which is described as Orthogenesis; these probably are the 'mutations' of Waagen.

All the processes in column IV. are those which may be observed at the time or moment of observation in any organism, provided we have sufficient keenness of perception or sufficient knowledge to discriminate between them.

The elements of comparison given in column V., on the other hand, relate strictly to questions of origin, or to the past and the future, also to questions of comparison. The first broad distinction of comparison is between I., Homologous, and II., Analogous characters. In a strict interpretation homologous refers only to those elements which are 'homogeneous' (Lankester), or have an actual similarity of origin or ancestry. Under analogous characters there is a simple distinction to be drawn between the results of parallelism and of convergence, terms which I maintain should be used in a somewhat stricter sense than they have been hitherto. Looking to the past and future, we have III., the non-analogous characters and the broad phenomena of divergence. Appreciation of animal divergence, or of divergence in special structures and organs, naturally belongs to the evolutionary period of anatomical thought; a period beginning with the branching system of Lamarck and continued in the still clearer perception of divergence in the writings of Darwin. I have elsewhere proposed to employ the term 'adaptive radiation' for the general phenomenon of divergence as observed in a single group, distinguishing such a group in process of divergence as a 'radiation,' either a 'continental radiation' where diverging on a large scale, or a 'local radiation' where diverging in a more restricted environment.

It will be observed that while these ideas and terms are all evolutionary they are also *purely anatomical,* and restricted to anatomy. In a second communication the ideas and terms of modern evolution will be similarly treated.

HENRY F. OSBORN.

SOME PH.D. STATISTICS.

WE do not have to go very far back in the annals of higher education in the United States to discover a period when the percentage of instructors at a given university who had received the doctorate from the same institution, excluding foreign degrees, came perilously near the maximum. During the last ten or fifteen years, however, quite a change

has been effected in this respect, so that at the present day there are few prominent universities in the country where the number of faculty members who hold a Ph.D. degree from another university is not larger than the number of those who received the degree from the institution in which they are giving instruction. There has been a noticeable change during the past decade also in the percentage of degrees received from foreign universities, and while there has been no perceptible decrease in the actual number of degrees taken abroad, there has been of course a considerable increase in the number conferred by American universities. In 1884 only 28 Ph.D. degrees were granted on examination by American universities; ten years later (in 1894) there were 233, and fifteen years later (in 1899) there were 325.

Chicago, Columbia, Cornell, Harvard, Johns Hopkins, Pennsylvania and Yale are the universities that are turning out the largest number of doctors, and it may be of interest to know how these universities, as well as a number of other representative institutions of higher learning, stand in the matter of 'inbreeding.' In the following figures only instructors of professorial rank, having a seat in one or another of the university faculties, are considered. In only three institutions is the number of degrees received from the home university larger than that received elsewhere, namely, in the case of Yale, where 46 of the 67 professors holding the Ph.D. degree, or 69 per cent., received it from Yale and 21 from other institutions; in the case of Johns Hopkins, where 27 out of 41, or 66 per cent., received it from Johns Hopkins and 14 from elsewhere; and in the case of Pennsylvania, where 26 out of 45, or 58 per cent., received it from Pennsylvania and 19 from elsewhere. The other institutions from which figures were secured run in the following order, the figures representing in each case the number and percentage of professors who received the degree from the home university: Cornell 32 out of 70, or 46 per cent.; Columbia 32 out of 73, or 44 per cent.; Michigan 10 out of 25, or 40 per cent.; Harvard 21 out of 55, or 38 per cent.; Princeton 12 out of 33, or 36 per cent.; Chicago 25 out of 86, or 29 per cent.; Wisconsin 13 out of 49, or 27 per cent.; California 4 out of 46, or 9 per cent. It is only natural that universities like California, Wisconsin and Chicago should have a high percentage of Ph.D.'s from elsewhere on their faculties.

The above figures also show that in the actual number of doctorates held by members of the faculties the universities rank in the following order: Chicago, Columbia, Cornell, Yale, Harvard, Wisconsin, California, Pennsylvania, Johns Hopkins, Princeton and Michigan. Chicago also has the largest number of Ph.D.'s from elsewhere, followed by California, Columbia, Cornell, Wisconsin and Harvard.

The following universities in the order named are represented by the largest number of doctors of philosophy at the institutions above enumerated, excluding in each case the degrees granted by the same university: Johns Hopkins, Harvard, Yale, Columbia, Princeton and Pennsylvania. Among foreign universities, Leipzig has by far the largest representation, having 37 doctors of philosophy on the faculties of the universities under discussion, as against 40 from Johns Hopkins. The other universities represented by more than one doctor follow in the order named: Göttingen, Halle, Berlin and Munich (10 each), Freiburg, Heidelberg, Strassburg, Jena and Rostock and Würzburg (2 each). Complete returns were not made by every institution, but the figures are close enough to reflect existing conditions with sufficient accuracy.

The statistics prove that most of the universities concerned attract to their faculties a considerable percentage of holders of Ph.D. degrees from other institutions, that Yale, Johns Hopkins and Pennsylvania are the chief exponents of 'inbreeding,' that the western universities, as might be supposed, draw the largest percentage of doctors from elsewhere, that Johns Hopkins has the largest Ph.D. representation of any American university,

and Leipzig of any foreign university, on the faculties of the institutions under discussion.

RUDOLF TOMBO, JR.,
Registrar.

COLUMBIA UNIVERSITY.

BOTANICAL NOTES.

MICHIGAN FORESTRY.

THAT rational views as to forestry are steadily growing in popular favor is shown by the increasing attention which is given the subject by state and local organizations. The recent appearance of the report of the Michigan Forestry Commission forcibly emphasizes the changed attitude of the people with reference to the forests. Many years ago the writer was an interested eye witness of the lumbering operations which finally denuded the state of its fine forests, and at that time nothing that any one said had the least effect in staying the hands of the destroyers. There was but one thing to be done with the forests, and that was to destroy them. And now, alas, when it is too late to save even a remnant of the magnificent tree growth the public conscience has been awakened, and the enormity of the crime is beginning to be realized.

The report enumerates the steps taken by the commission in the campaign of education which it has inaugurated, and includes the report of the warden of the state forest reserves (Professor Roth), followed by a collection of essays by a considerable number of public-spirited citizens, all tending to create an interest in the planting or conservation of forests. The forest reserves include about 34,000 acres near Higgins and Houghton lakes in Crawford and Roscommon counties. Originally almost all of the land of these reserves was covered by heavy forest of pine, cedar, tamarack and some hardwoods. In a few striking sentences Professor Roth tells the story of the destruction of the great forest, and the transformation of the sylvan landscape into a dreary waste. It is a pitiful tale of greed for gain coupled with utter carelessness as to the future of the country. Photographs make very real the story he so graphically tells. Yet other photographs give us a view of the more cheerful story which may be told in the future when the seedlings now springing up are allowed to grow into a new forest. If the fires are kept out these areas may again be covered with trees. To this end the commission is working, and in this laudable undertaking every scientific man in the country will wish them Godspeed.

A NEW BOOK ON ECOLOGY.

AT last, after much delay, the University Publishing Company, of Lincoln, Nebr., has issued Professor Clement's book on 'Research Methods in Ecology.' An adequate review of this important contribution to modern botany will appear in due time, and it is only necessary to say now that it analyzes critically the problems which confront the practical ecologist (theoretical ecologists appear to have no such difficulties), and discusses the methods of solution with great detail, in which many illustrations and descriptions of instruments are used.

ORIGINAL DESCRIPTIONS OF SPECIES.

A. A. HELLER, of Los Gatos, California, has undertaken the publication of a series of fascicles in which appear the original descriptions of all of the North American species of certain genera of plants. He has already issued such fascicles for *Lupinus, Trifolium, Ribes, Castilleia* and *Artemisia,* including descriptions of 464 species. Each species is given a separate sheet, and the sheets for each genus are enclosed in special manila paper covers. The cheap price of these reprints (about one cent each) places them within the reach of all botanists who are interested in this department of systematic botany.

NORTH AMERICAN RUSTS.

PROFESSOR HOLWAY, of the University of Minnesota, has begun the publication of an important work on the rusts, entitled 'North American Uredineae,' of which Part 1 of Volume I. has just appeared. This part is a quarto pamphlet of 32 pages of text, accompanied with ten photomicrograph plates of

uredospores and teleutospores. The arrangement is by hosts, the present part being devoted to the species of *Puccinia* parasitic on certain Ranunculaceae (*Caltha, Delphinium, Anemone, Pulsatilla, Clematis, Trautvetteria, Ranunculus, Cyrtoryncha*), Berberidaceae (*Berberis, Podophyllum*), Papaveraceae (*Capnoides*), Bromeliaceae (*Pitcairnia*), Commelinaceae (*Commelina*), Juncaceae (*Juncoides*), Liliaceae (*Chrosperma, Veratrum, Xerophyllum, Zygadenus, Allium, Brodiaea, Calochortus, Asparagus, Clintonia, Aletris, Smilax*), Amaryllidaceae (*Cooperia, Bomarea*), Iridaceae (*Iris*), Orchidaceae (*Cypripedium*, unknown orchid). The photographs are excellently reproduced, and with the full descriptions (all drawn from the specimens) should prove very helpful to the student of these plants.

Charles E. Bessey.
The University of Nebraska.

MUSEOGRAPHY.

An historical and bibliographical work of great value is that recently published by Dr. David Murray, of Glasgow, under the title of 'Museums, their History and their Use' (3 vols., Glasgow, 1904). The first volume forms a notable repository of information concerning the development of the museum as a scientific institution, beginning with the earliest times. Interspersed with accounts of the older museums and their exhibits are brief notices of scientific workers, together with their contributions and attitude of mind toward controverted questions. An excellent summary is given, for instance, of the discussion of fossils amongst learned circles of two and three hundred years ago and earlier.

The author remarks that his purpose has been to provide, in the first place, 'a short list of the books bearing on the bibliography of museums, which I had found useful, that is, a bibliography of bibliographies.' The next subject, museography, is dealt with more fully, but not exhaustively, after which is given a selection of books on the practical work of museums—the collection, preparation and preservation of specimens, their registration and exhibition. Nearly the whole of the second and third volumes is devoted to catalogues and other works relating to particular museums and special collections. Not the least important section of the work contains individual suggestions and criticisms on the part of the author, his extensive acquaintance with museums the world over rendering all that he has to say timely and instructive. Yet on the whole the work is written from the archeological standpoint, rather than the technical, or purely scientific.

C. R. E.

THE UNIVERSITY OF WISCONSIN.

The legislature of Wisconsin has passed a law giving the University of Wisconsin two sevenths of a mill tax for current expenses, and has made a special appropriation of $200,000 a year for three years for constructional and other emergency work. On the basis of the present assessed valuation the two sevenths of a mill tax will yield $525,000, which with the $200,000 make the appropriation from the state $725,000, even if there is no increase in the assessed valuation. The other sources of income are sufficient to make the budget of the university for the coming year about $1,000,000.

A number of appointments and promotions have been made: E. B. McGilvary, A.M. (Princeton), Ph.D. (California), Sage professor of moral philosophy of Cornell University, has been appointed professor of philosophy; and Edward C. Elliott, B.S. (Nebraska), Ph.D. (Columbia), now instructor in Teachers College, Columbia University, associate professor of education. Dr. Charles E. Mendenhall has been promoted to a professorship of physics; Dr. Frank C. Sharp to a professorship of ethics; C. F. Burgess to a professorship of engineering, and Ransom A. Moore, to a professorship of agronomy. Albert H. Taylor has been promoted to be assistant professor of physics; Leonard S. Smith, to be associate professor of topographic and geodetic engineering; Herbert F. Moore, to be assistant professor of mechanics, and Edwin G. Hastings to be assistant professor of agricultural bacteriology.

Instructors have been appointed as fol-

lows: *Mathematics*—R. S. Peotter, B.S. (Wisconsin), and R. A. Moritz, B.S., M.A. (Wisconsin). *Physics*—Leonard R. Ingersoll, B.S. (Colorado College), now fellow in physics. *Chemistry*—Roy D. Hall, B.S., M.S. (Wisconsin), Ph.D. (Pennsylvania); F. L. Shinn, B.S. (Indiana); Harry B. North, Ph.G., B.S. (Wisconsin), now assistant, and Edgar B. Hutchins, B.S. (Ottawa), M.S., Ph.D. (Wisconsin). *Education*—Walter F. Dearborn, A.B., A.M. (Wesleyan), Ph.D. (Columbia). *Mechanics*—M. O. Withey, C.E. (Thayer). *Mechanical drawing*—E. S. Moles, B.S (Wisconsin), and John E. Boynton, B.S. (Wisconsin). *Topographical engineering*—Ray Owen, B.S. (Wisconsin). *Hydraulic engineering*—Charles J. Davis, C.E. (Cornell). *Electrical engineering*—Frank J. Petura, B.S. (Wisconsin); George G. Post, B.S. (Wisconsin), now assistant, and John C. Potter, B.S. (Wisconsin), now assistant.

Assistants have been appointed as follows: *Anatomy*—David A. Crawford, B.A. (Wisconsin). *Botany*—William G. Marquette, B.A. (Wisconsin), now assistant; Ruth F. Allen, B.S. (Wisconsin). *Physics*—Willibald Weniger, B.A. (Wisconsin); R. A. Wetzler, B.S. (Minnesota); W. E. Wickenden, B.S. (Dennison); Elmer H. Williams, B.A. (Wisconsin); Archie S. Worthing (Wisconsin); Vernon A. Suydam, B.L. (Wisconsin); V. P. Spence, A.B. (Northwestern). *Zoology*—A. B. Clawson, B.S., M.S. (Michigan). *Civil Engineering*—R. F. Ewald, B.S. (Wisconsin).

THE MUSEUM OF THE BROOKLYN INSTITUTE.

ON June first the central section of the museum of the Brooklyn Institute was opened to the public, as well as the halls that have been temporarily closed, owing to the installation of new collections and the rearranging of the picture galleries. The ethnological collections obtained by Mr. Culin during two seasons' work in Arizona and New Mexico are shown for the first time. They occupy the hall formerly devoted to casts from the antique, and comprise a well-balanced series illustrating the arts and industries of the Pueblo Indians, while special attention has been given to objects pertaining to their religious ceremonies. There are thus displayed about 200 small figures representing the costumes worn by the dancers and 100 of the actual masks worn on these occasions, this being much the most complete collection in any museum.

The natural history collections have been completely rearranged during the past year and extensive additions made to them, but, owing to the architectural features of the central section a thoroughly systematic arrangement will not be possible until the completion of the new wing now in process of construction. Among the special collections still in process of installation may be mentioned one illustrating the problem of flight and the various adaptations by which it has been solved in nature, and one illustrating individual, sexual, seasonal and geographic variation. The latter includes eight of the thirteen sub-species of horned owls recognized by Mr. Oberholser, the contrast between the Alaskan, Hudsonian and desert forms being very striking. A group of Ellesmere Land musk oxen, *Ovibos moschatus wardi,* has also been placed on exhibition, which includes an old male, a female and yearling from the same herd.

AWARD OF THE BARNARD MEDAL.

THE Barnard medal of Columbia University has been awarded to M. Henri Becquerel. In making this award at the recent Columbia exercises, President Butler said: "In accordance with the terms of the will of Frederick A. P. Barnard, tenth president of Columbia University, a gold medal is established, known as the Barnard medal for meritorious service to science. This medal is awarded at commencement at the close of every quinquennial period, to such person, if any, whether a citizen of the United States or of any other country, as shall, within the five years next preceding, have made such discovery in physical or astronomical science, or such novel application of science to purposes beneficial to the human race, as, in the judgment of the National Academy of Sciences, of the

United States, shall be deemed most worthy of such honor. The Barnard medal was first awarded at the commencement of 1895, to Lord Rayleigh, and to Professor (now Sir) William Ramsay. At the commencement of 1900 the Barnard medal was awarded to Professor Wilhelm Conrad von Röntgen. On the nomination of the National Academy of Sciences, the award for 1905 is made to Henri Becquerel, member of the Institute of France, for important discoveries in the field of radio-activity, and for his original discovery of the so-called dark rays from uranium, which discovery has been the basis of subsequent research into the laws of radio-activity, and of our present knowledge of the same."

THE AMERICAN ANTHROPOLOGICAL ASSOCIATION.

The American Anthropological Association will meet in San Francisco, California, August 29–31. It is planned to combine the meeting with an excursion by the association to the Lewis and Clark Centennial Exposition at Portland. Arrangements will be made facilitating the visit by members of the association to educational and other points of interest on the Pacific Coast. This will be the first meeting of the association, or of any body of national scope devoted to anthropology, held on the Pacific Coast, and a large attendance from the western states is expected. Professor F. W. Putnam will preside.

Titles of papers and applications for membership should be sent to Dr. A. L. Kroeber, secretary of the committee on arrangements, Affiliated Colleges, San Francisco, or to Dr. George G. MacCurdy, secretary of the association, Yale University, New Haven, Conn. The headquarters of the association will be the Museum of the Department of Anthropology of the University of California, Affiliated Colleges, San Francisco. Further information in regard to special railway rates and other arrangements connected with the meeting may be obtained from Dr. MacCurdy.

SCIENTIFIC NOTES AND NEWS.

Princeton University has conferred the degree of Doctor of Laws on Professor Charles Augustus Young, who has this year become professor emeritus of astronomy, after holding the chair at Princeton since 1877.

Columbia University has conferred the degree of Doctor of Science on Dr. R. S. Woodward, who has resigned the chair of mechanics and mathematical physics to accept the presidency of the Carnegie Institution.

Oxford University will on June 28 confer its Doctorate of Science on George H. Darwin, F.R.S., professor of astronomy at Cambridge.

The University of Manchester has conferred the honorary degree of LL.D. on Dr. Nicholas Murray Butler, president of Columbia University.

Syracuse University has awarded the degree of LL.D. to Professor David Eugene Smith, who holds the chair of mathematics at Teachers College, Columbia University.

The University of Colorado has conferred the degree of Doctor of Laws upon Dr. Richard W. Corwin, chief surgeon of the Colorado Fuel and Iron Co.

Columbia University has conferred the degree of M.S. on George Francis Sever, professor of electrical engineering in the university, and on Frederick A Goetze, superintendent of buildings and grounds.

Mr. W. T. Brigham, director of the British Museum of Ethnology at Honolulu, has been given the degree of Doctor of Science by Columbia University. He was presented by Dr. H. C. Bumpus, director of the American Museum of Natural History.

Professor H. A. Lorentz, of Leiden, has been elected a corresponding member of the Berlin Academy of Sciences.

At the commencement exercises of the University of Pennsylvania a portrait of Dr. William Osler was presented by Professor Howard M. Fussell, on behalf of the classes from '85 to '91, who studied under Dr. Osler when he occupied the chair of clinical medicine at the university.

The Glasgow University Club of London held its annual dinner on May 26, when Sir William Ramsay presided. Lord Kelvin was

elected president of the club for the ensuing year.

AT the annual meeting of the Iron and Steel Institute held in London, May 11, a Carnegie research scholarship of $500 was awarded to Henry Cook Boynton, instructor in metallurgy and metallography in Harvard University.

MR. C. D. HOWARD, associate chemist of the West Virginia Agricultural Station, has been appointed chemist to the New Hampshire Board of Health, Concord, N. H.

DR. AUGUST HOCH, at present assistant physician and pathologist at McLean Hospital, Waverly, Mass., will assume the position of first assistant physician at Bloomingdale Asylum, White Plains, N. Y., where he will continue his researches in psycho-pathology.

DR. W. B. SCOTT, professor of geology and paleontology at Princeton University, gave the oration at a joint meeting of Phi Beta Kappa and Sigma Xi societies at the University of Pennsylvania, on June 14.

DR. A. S. WHEELER, associate professor of organic chemistry in the University of North Carolina, will give a course of lectures on organic chemistry at the Harvard University summer school.

IN commemoration of Audubon's one hundred and twenty-fifth birthday, the American Museum of Natural History has placed on exhibition a collection of Audubon relics. Among the objects is the portfolio in which Audubon carried specimen plates while securing subscribers to his great work in this country and abroad, together with sketches and finished plates.

A SECOND International Congress devoted to the Rontgen rays will be held in Amsterdam in 1908.

The British Medical Journal states that the Laryngological Society of Vienna is about to take steps to organize a festal celebration to be held in 1908 in honor of the jubilee of medical, as distinguished from physiological laryngoscopy. It was in 1858 that Professor Turck showed the far-reaching applications in the domain of medical practice of Manuel Garcia's great discovery. It is hoped that all the leading representatives of laryngology throughout the world will be present on the occasion.

The Scottish Geographical Magazine states that an expedition has recently started with the object of thoroughly investigating the oceanography and biology of the region between India and Madagascar. The vessel employed is H.M.S. *Skylark,* under the command of Captain Boyd Somerville, who is accompanied by two civilian men of science, Mr. Stanley Gardiner and Mr. Forster Cooper, both of whom have already been engaged in scientific work in the area under investigation. The *Skylark* is to go first to the Chagos Archipelago, then to Mauritius, which it is expected will be reached about August 1. The voyage will then be continued *via* the Cargados reef to the Seychelles, whence the return will be made to Colombo, the starting-point. Messrs. Gardiner and Cooper are to be left at the Seychelles, where they hope to spend some months in scientific work, returning home in January, 1906.

IT is stated in *Nature* that at the forty-second general meeting of the Institution of Mining Engineers, held in London on June 2 and 3, several interesting papers were read. Mr. T. Y. Greener dealt with the firing of boilers by waste heat from coke ovens. Mr. M. R. Kirby described the compound winding engine at Lumpsey iron mine. Its steam consumption is only 38 pounds to 40 pounds per indicated horse-power hour. Mr. F. Hird gave the results of tests of the electric winding engine at Friedrichshall, and Mr. E. Lozé described electric winding engines installed at French collieries. Mining education in the United States was discussed by Professor H. Eckfeldt, and in New Zealand by Professor J. Park. Coal mining in India was dealt with by Mr. T. Adamson. Mr. J. Jeffries described the occurrence of underground fires at the Greta colliery, New South Wales. Mr. W. C. Blackett and Mr. R. G. Ware described a striking innovation in mining practise, the use of electrically driven mechanical conveyors for filling at the coal-face. Two years' experience has shown a saving of 48 per cent. over the ordinary pick and shovel method.

Lastly, Mr. A. R. Sawyer gave an account of the geology of Chunies Poort, Zoutpansberg, Transvaal. Incidentally, he mentioned some old copper workings where native copper occurs in some abundance in dolomite.

The Naturwissenschaftliche Verein at Karlsruhe has, thanks to a considerable legacy, been placed in a position to establish two new stations for seismic observations, the one in an underground passage at Turmberg, near Durlach, the other in Freiburg.

The London *Times* states that a large company assembled in the Oxford University Museum on May 31 at the annual *conversazione* of the Junior Scientific Club. An attractive program had been arranged. Professor E. B. Poulton, F.R.S., delivered a lecture on 'Some Recent Work on Protective Resemblance and Mimicry in Insects,' and Dr. A. E. Tutton displayed some of his latest lantern slides of Alpine scenery. There were demonstrations of the properties of radium and spinning tops, experiments on color, and an exhibition of thermit and high temperatures, which included the making of artificial diamonds. Messrs. Zeiss exhibited their instrument for seeing ultra-microscopic particles, and there was a working installation of wireless telegraphy. The Pitt-Rivers Museum was thrown open, and music was provided by the band of the Grenadier Guards.

Nature says that under the name of the 'Potentia Organization,' an international association has been formed with the object of establishing among nations a mutual relationship and cooperation for the diffusion of accurate information and unbiased opinion concerning international events and movements, and to combat narrow, prejudiced, and often interested views and news that contribute so much to international mistrust and misunderstanding. It is proposed to publish throughout the world, through the medium of newspapers and reviews, statements of simple fact and expressions of opinion by eminent public men of all nations on all important political, social, philosophical, economic, scientific and artistic questions, to present the sincere views of experts on all current international events, and to refute false or biased news and views calculated to spread error and to endanger the peace and progress of the world.

UNIVERSITY AND EDUCATIONAL NEWS.

At the commencement of Princeton University it was announced that an annual income of $100,000 had been guaranteed for the preceptorial system, that $300,000 had been given for a recitation hall and that 336 acres of land had been added to the property of the university.

Mr. Morris L. Clothier, of Philadelphia, has given $50,000 to Swarthmore College, to endow a professorship of physics.

The library building of Vassar College, erected by Mrs. F. F. Thompson, of New York, at a cost of $500,000 was dedicated last week.

Dr. A. W. Harris, director of the Jacob Tome Institute, and previously director of the Office of Experiment Stations of the Department of Agriculture, has been elected president of Northwestern University.

Mr. Henry S. Drinker, general solicitor of the Lehigh Valley Railroad, has been elected president of Lehigh University, to succeed the late Dr. Thomas Messinger Drown.

Dr. Charles Henry Smyth, professor of geology at Hamilton College, has been elected professor of geology at Princeton University.

Dr. Nicholas Senn has been elected professor of surgery and Dr. Frank Billings professor of medicine at the University of Chicago.

Dr. H. K. Wolfe, formerly professor of philosophy at the University of Nebraska and recently principal of the Lincoln High School, has been elected professor of philosophy and education at the University of Montana.

Mr. W. L. Hall, of the U. S. Bureau of Forestry, has been appointed lecturer on tree planting at Yale University.

Ivan E. Wallin, B.S. (University of Iowa, '05), has been elected professor of natural history in Upsala College, New Orange, N. J. He has been specializing in the biological sciences at Augustana, Princeton and Iowa during the last three years.